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(54) **TARGET ACTIVATED SENSOR**

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Related U.S. Application Data

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(51) **Int. Cl.**

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B60N 2/07	(2006.01)
G01B 7/02	(2006.01)
G01D 5/14	(2006.01)
G01B 7/00	(2006.01)
B60N 2/02	(2006.01)

(52) **U.S. Cl.**

CPC ***B60N 2/0705*** (2013.01); ***G01B 7/023*** (2013.01); ***G01D 5/145*** (2013.01); *B60N 2002/0272* (2013.01); *G01B 7/003* (2013.01)

(58) **Field of Classification Search**

CPC G01D 5/145; G01D 5/147; G01B 7/023; G01B 7/003

USPC 324/207.26, 207.2, 207.24, 251

See application file for complete search history.

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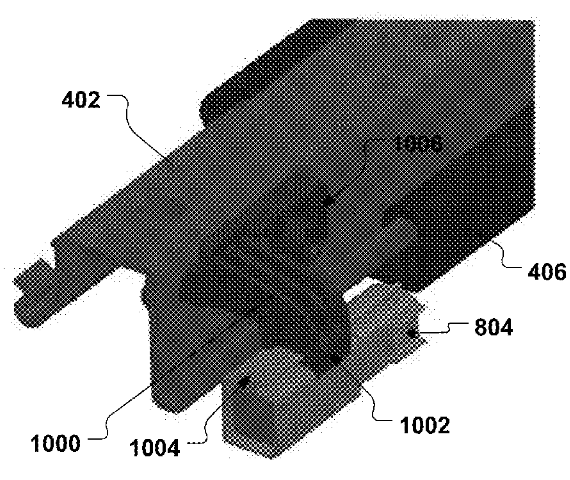
(57) **ABSTRACT**

A sensor assembly configured to sense a position of a seat in a vehicle includes a housing defining a cavity and having an open end. The sensor assembly may also include a carrier removably disposed in the housing cavity via the open end, wherein a permanent magnet may be disposed within a magnet cavity defined in the carrier, wherein the permanent magnet may establish a magnetic field. The sensor assembly may further include a single pole disposed within a pole cavity defined in the carrier and spaced from the permanent magnet and positioned in the magnetic field. In addition, the sensor assembly may include a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in the magnetic field and adjacent to an end of the single pole. The magnetic sensor element and PCB may be at least partially disposed within the cavity.

14 Claims, 9 Drawing Sheets



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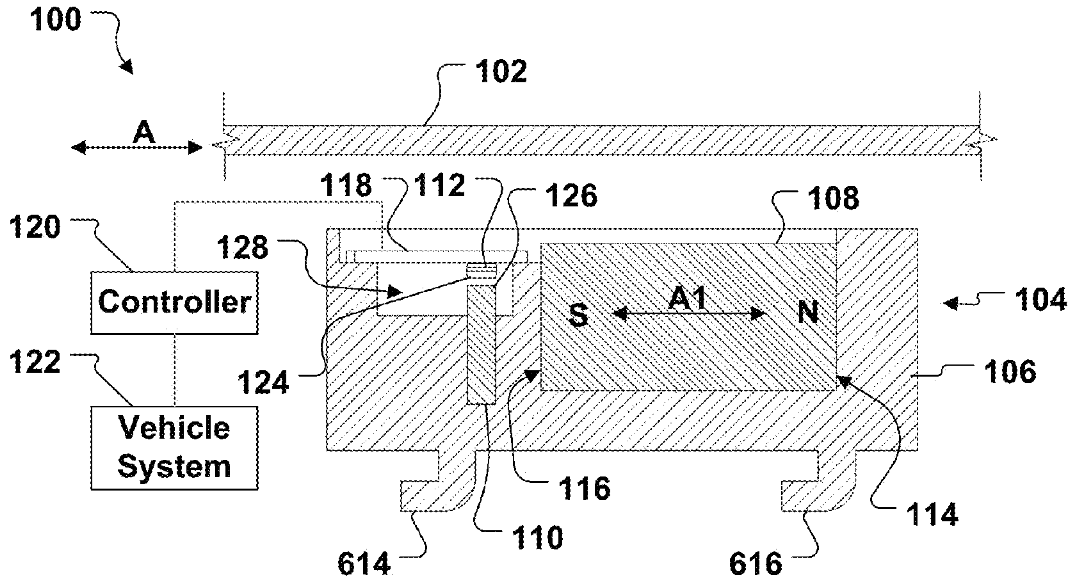

FIG. 1
(PRIOR ART)

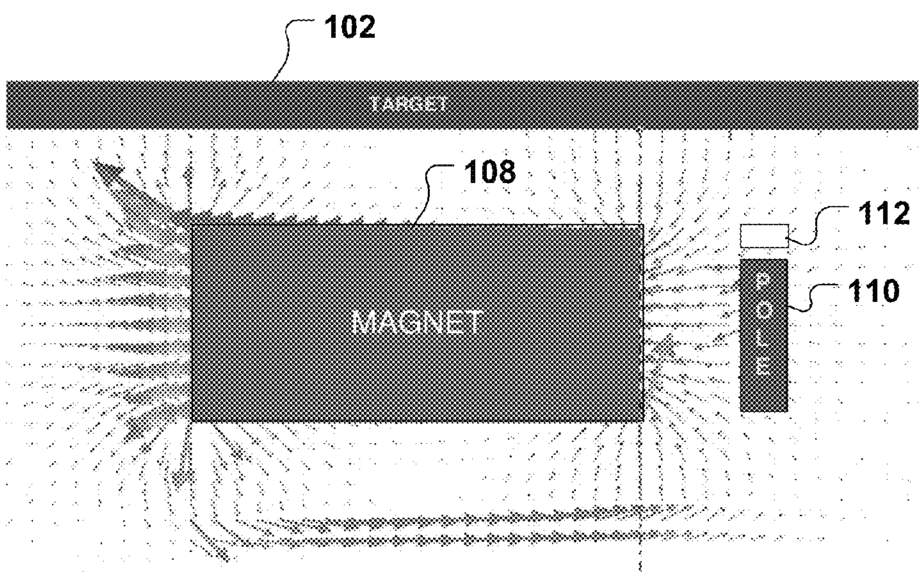

FIG. 2
(PRIOR ART)

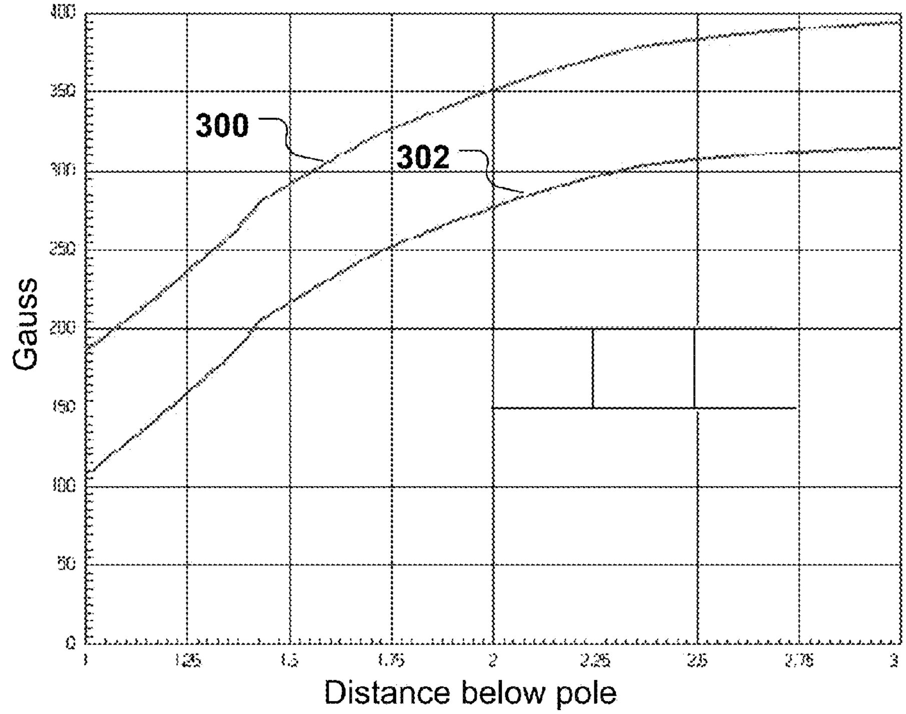

FIG. 3
(PRIOR ART)

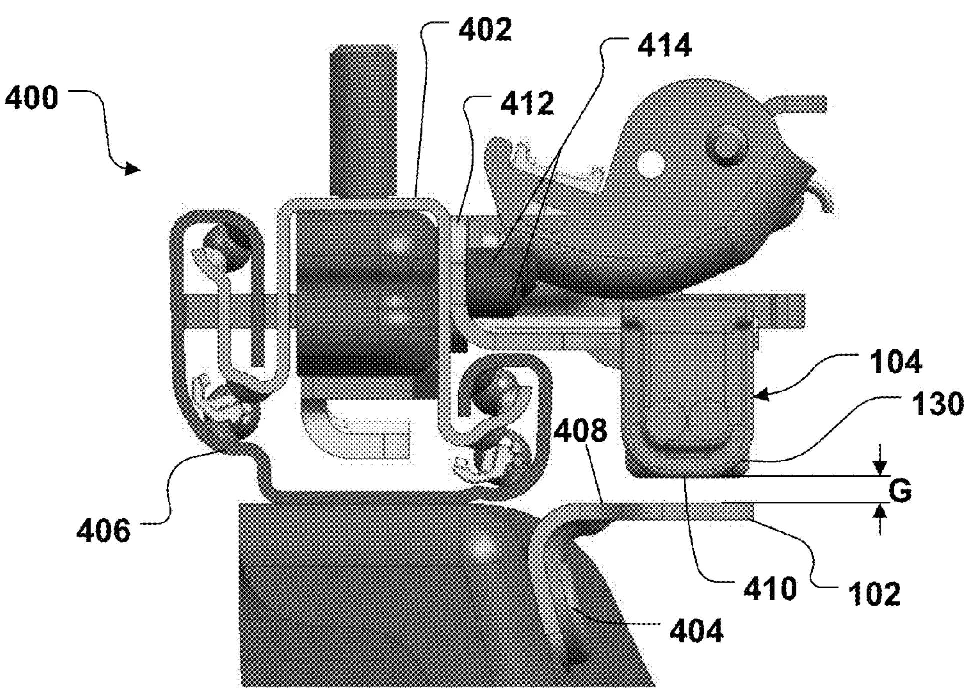

FIG. 4
(PRIOR ART)

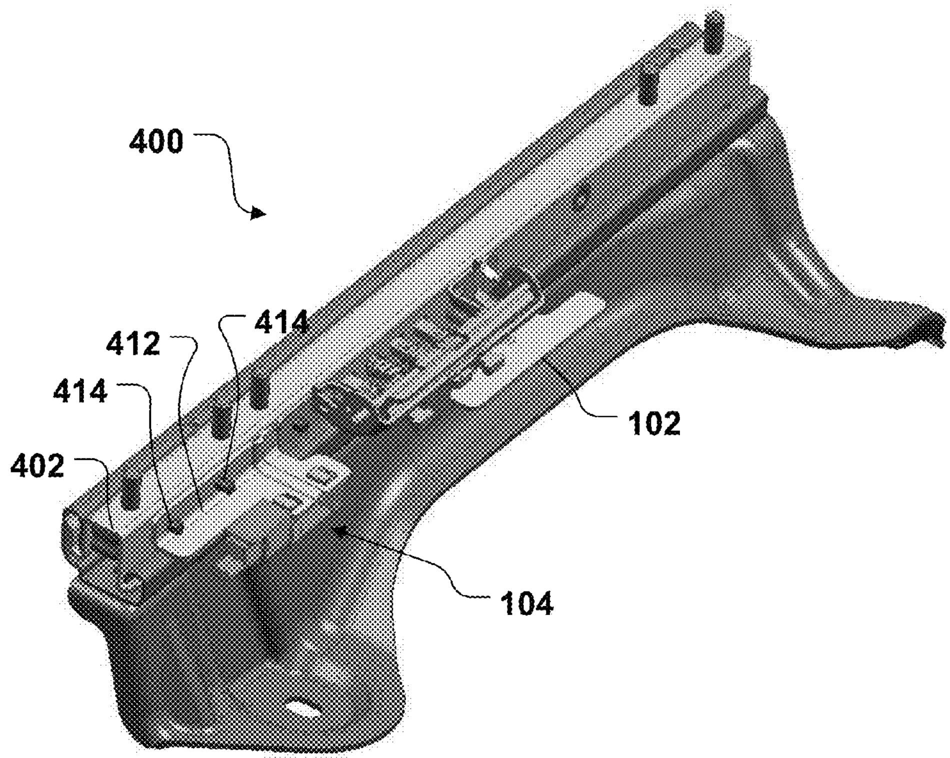

FIG. 5
(PRIOR ART)

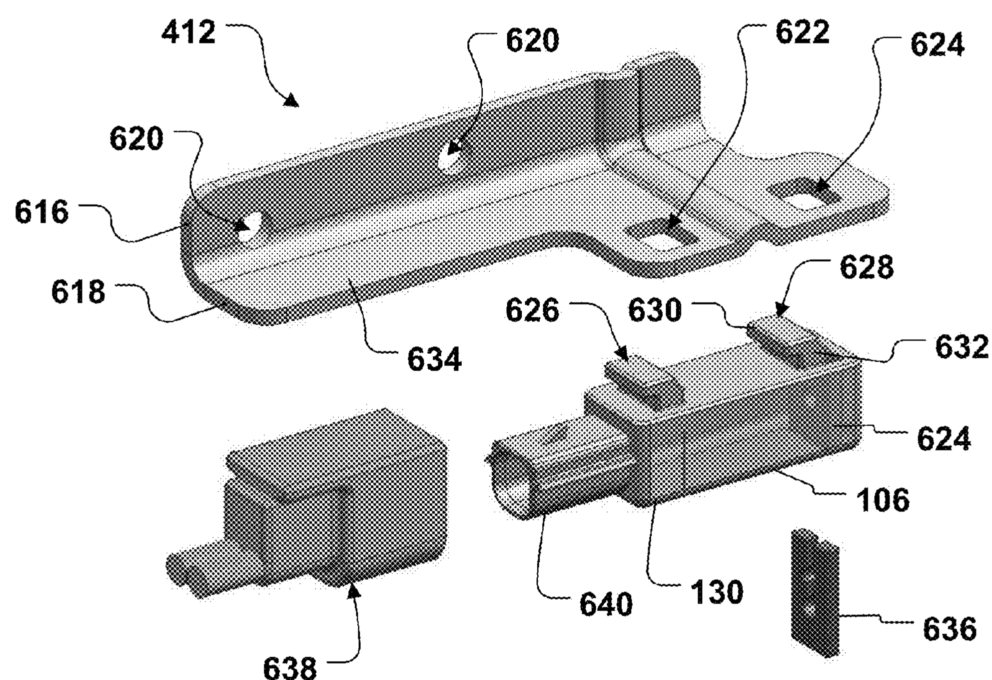

FIG. 6
(PRIOR ART)

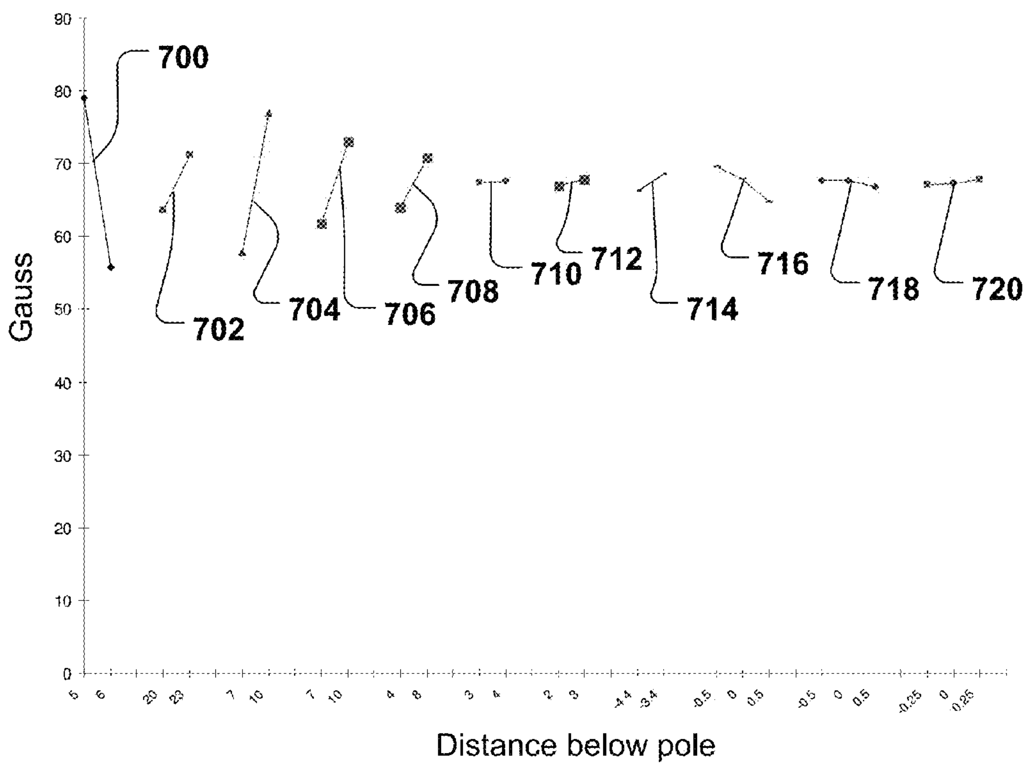

FIG. 7
(PRIOR ART)

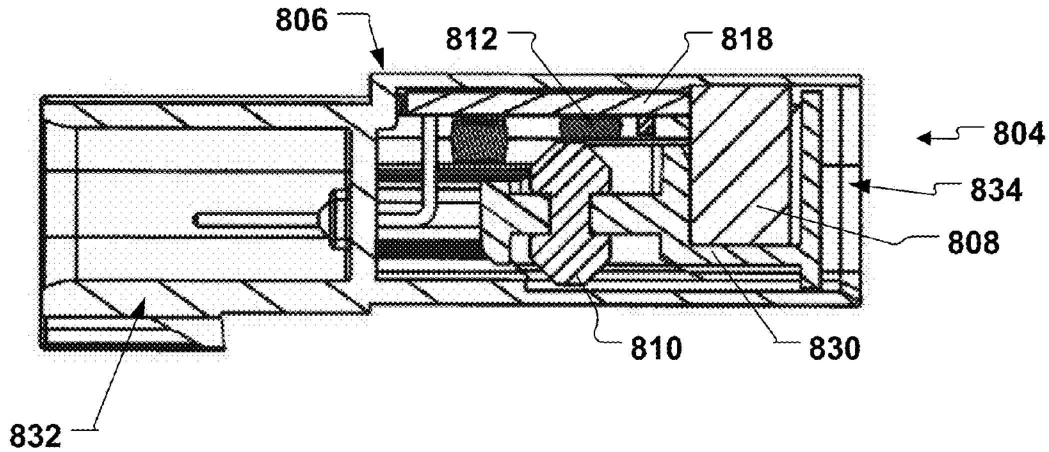
806
812
818
804
834
808
810
830
832

FIG. 8

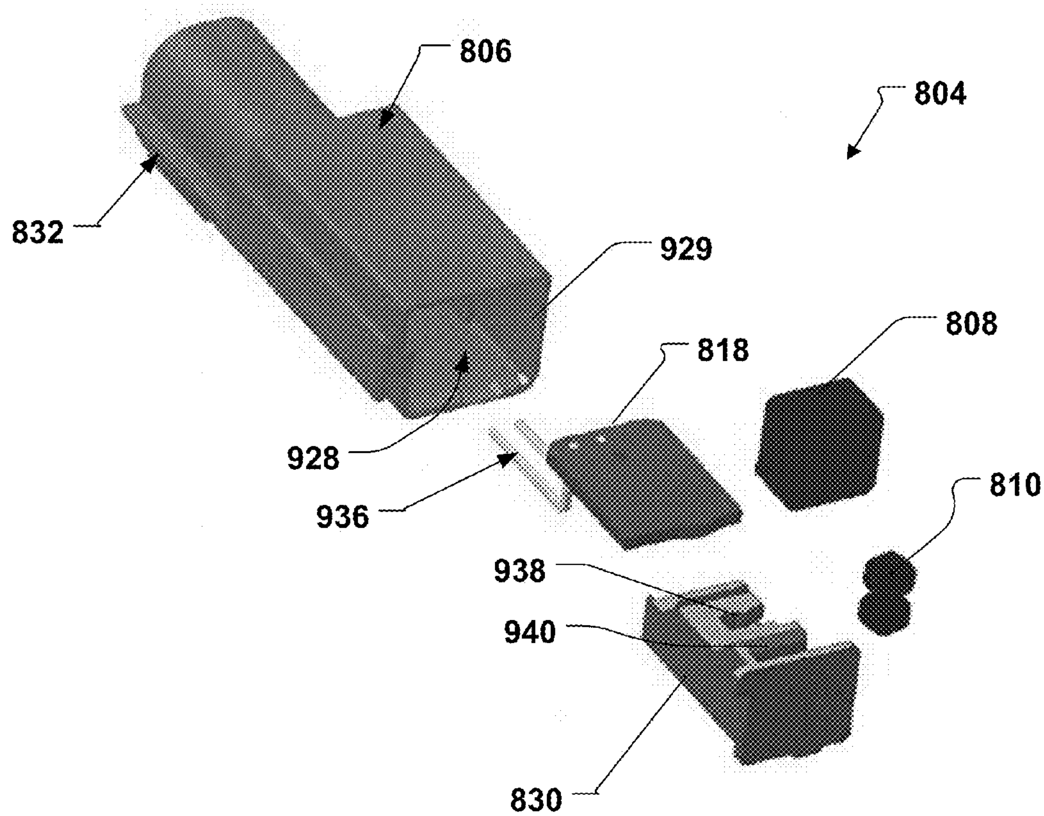
806
804
832
929
808
818
928
936
810
938
940
830

FIG. 9

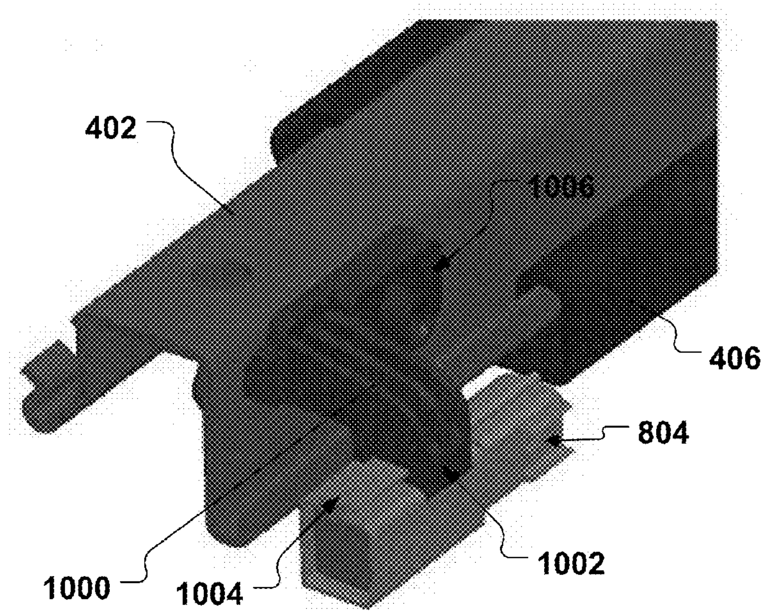
402
1006
406
804
1002
1000
1004

FIG. 10

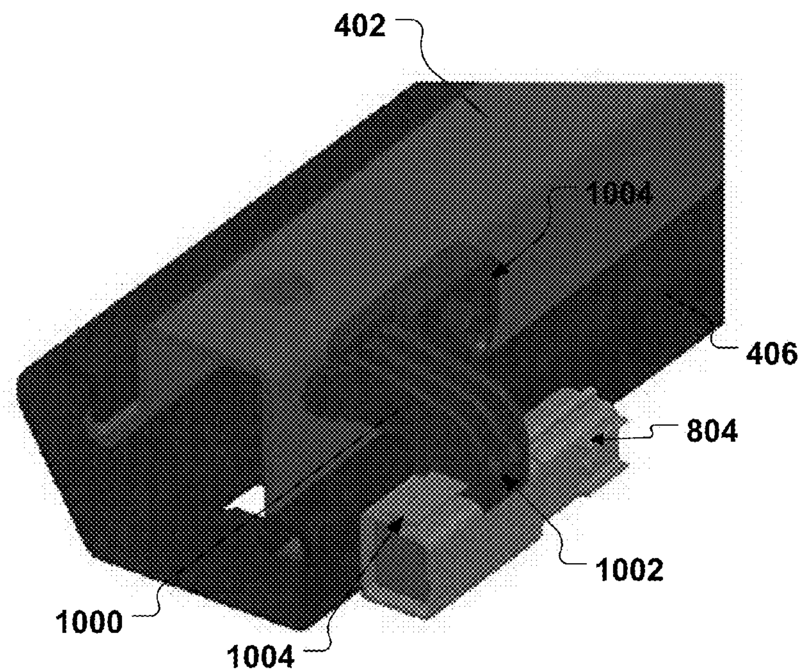
402
1004
406
804
1002
1000
1004

FIG. 11

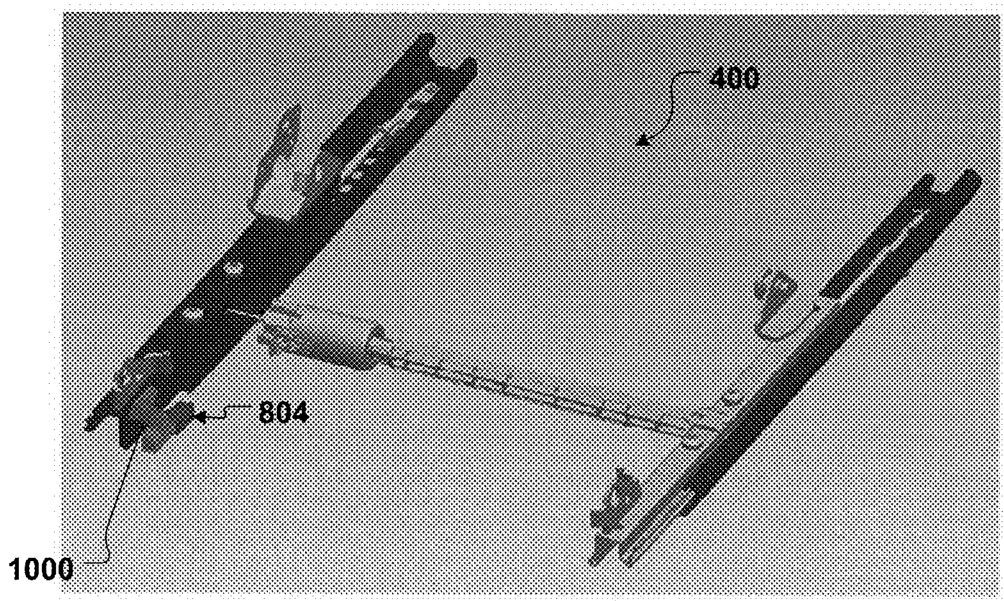

FIG. 12

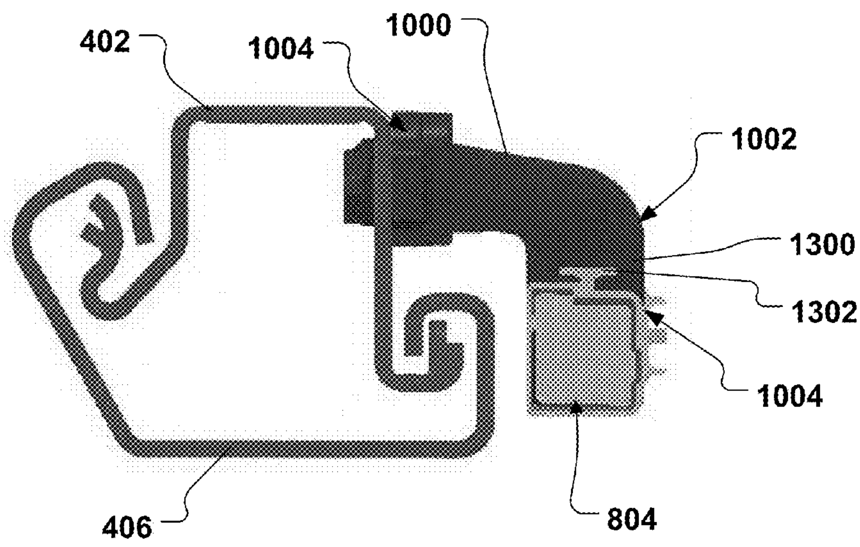

FIG. 13

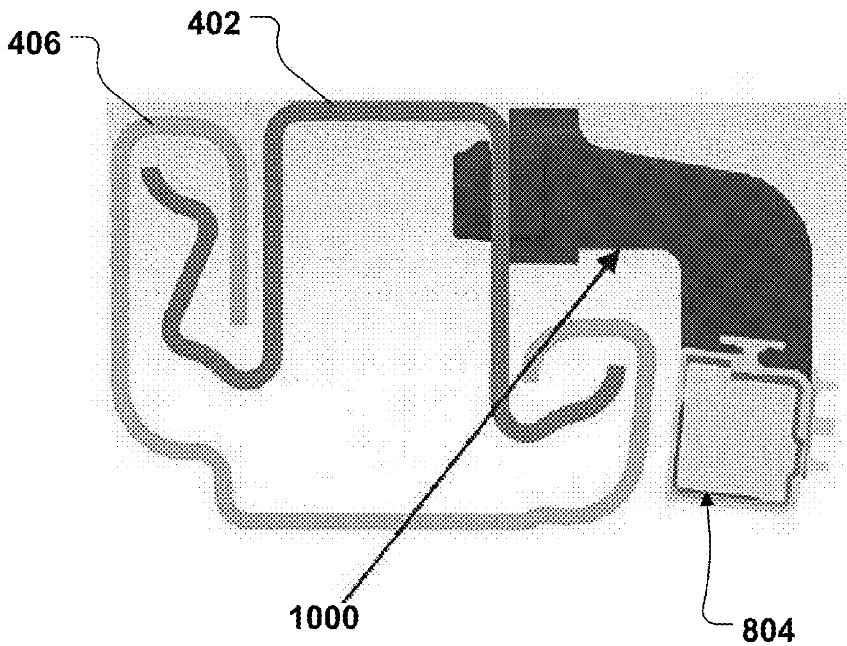

FIG. 14

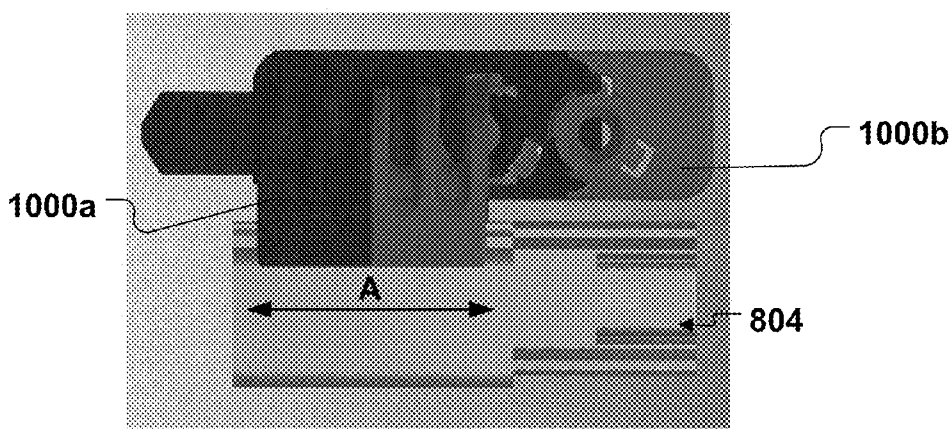

FIG. 15

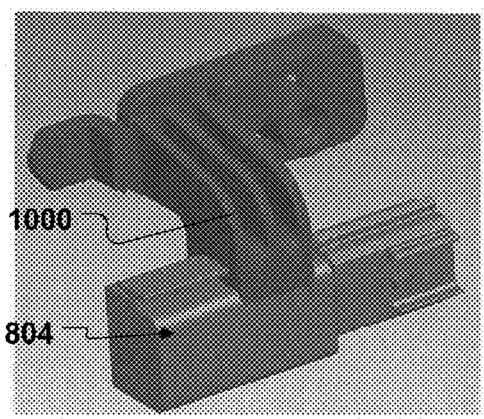

FIG. 16

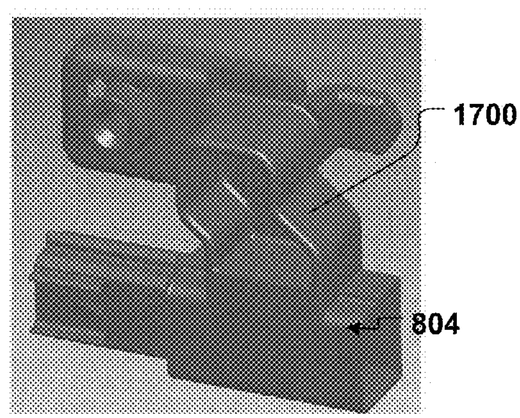

FIG. 17

TARGET ACTIVATED SENSOR

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/314,785, filed Mar. 17, 2010, the entire disclosure of which is incorporated herein by reference. Additionally, the present application is related to U.S. Pat. No. 7,193,412, the teachings of which are incorporated herein by reference.

FIELD

The present disclosure relates generally to position sensors, and, more particularly, to a target activated sensor that provides an output indicative of a position of a target relative thereto.

BACKGROUND

In a wide variety of applications it is advantageous or necessary to sense the position of a linearly or rotationally movable element. For example, in automobile seat applications the seat may be linearly movable, either manually or automatically via electro-mechanical means, on an associated track assembly. A sensor may provide a signal representative of the linear position of the seat on the track for a variety of purposes, e.g. to control deployment of an air bag, to control the electro-mechanical actuator that causes translation of the seat in connection with a seat position memory feature, etc.

For a seat position application, it is increasingly desirable for a sensor to provide multiple position outputs for purposes of ascertaining occupant position. For example, in applications where seat position is used to control air bag deployment early configurations involved only single stage air bag systems. A single stage air bag deploys with a known deployment force that may not be varied. In this application, seat position information was used only to determine when the airbag should be deployed. However, the advent of dual stage air bags, i.e. air bags that may be deployed with two distinct deployment forces, required increased resolution in position sensing. Also, the industry has moved to variable stage airbags where the deployment force may be varied depending upon occupant position and classification. Variable stage airbag configurations require a sensor configuration that can detect multiple seat positions for use in determining the appropriate deployment force.

Another desirable feature of a position sensor, especially in the context of an automobile seat application, is that it be a non-contact sensor. A non-contact sensor includes a sensing element that does not physically contact the sensed object, allowing quiet operation of the sensor and minimizing wear. Preferably, the sensor operates with a relatively large air gap between the sensor and the sensed object to avoid inadvertent contact due to manufacturing or assembly variances.

Another issue associated with seat position sensors is that the seat track environment is very crowded with limited physical space for such sensors. Also the space available for the sensor may vary among vehicle types. As such, sensors which are compact in size are desirable.

Accordingly, there is a need for a seat position sensor that is compact in size and is configured to operate with a relatively large air gap.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of the claimed subject matter will be apparent from the following detailed description of embodiments consistent therewith, which description should be considered with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic partial side-sectional view of an exemplary target activated position sensor consistent with the present disclosure;

FIG. **2** is a schematic diagram illustrating magnetic fields associated with an exemplary target activated position sensor consistent with the present invention;

FIG. **3** includes plots of gauss vs. distance showing magnetic flux at various distances from an end of a single pole when a target is present and when a target is not present in an exemplary target activated position sensor consistent with the present disclosure;

FIG. **4** is an end view of a portion of a vehicle seat assembly incorporating an exemplary target activated position sensor showing the target positioned in proximity to the sensor;

FIG. **5** is a side perspective view of the assembly of FIG. **4** showing the target positioned at a distance from the sensor;

FIG. **6** is an exploded view of one exemplary housing and mounting bracket configuration useful in connection with a target activated position sensor consistent with the present disclosure;

FIG. **7** includes plots of the difference in flux sensed by a magnetic sensor element when a target is present and not present vs. dimension showing the effect on the difference resulting from variation the dimension of eleven different component and tolerance variables associated with an exemplary target activated position sensor consistent with the present disclosure;

FIG. **8** is a schematic side-sectional view of an exemplary sensor assembly consistent with the present disclosure;

FIG. **9** is an exploded view of the assembly of FIG. **8**;

FIGS. **10**-**11** are perspective views showing the assembly of FIG. **8** mounted relative to first and second rails of a seat rail assembly;

FIG. **12** is a perspective view of a seat rail assembly consistent with the present disclosure;

FIGS. **13** and **14** are perspective views of the assembly of FIG. **8** mounted relative to first and second rails of a seat rail assembly; and

FIGS. **15**-**17** illustrate various mechanical connections for coupling a sensor assembly consistent with the present disclosure to a rail of a seat assembly.

DETAILED DESCRIPTION

For ease of explanation, sensor systems consistent with the invention will be described herein in connection with an automobile seat position sensing application. It will be recognized, however, that sensor systems consistent with the invention will be useful in other applications for sensing linear and/or rotational movement of an element. In addition, exemplary embodiments described herein include use of Hall Effect sensors and a magnet. Those skilled in the art will recognize, however, that a variety of sensing means may be used. For example, optical, magneto-resistive sensors, etc. may be useful in connection with a sensor system consistent with the invention. It is to be understood, therefore, that illustrated exemplary embodiments described herein are provided only by way of illustration, and are not intended to be limiting.

Referring to FIG. **1**, one exemplary target activated sensor system **100** consistent with the present invention is shown in detail. The illustrated exemplary sensor system includes a target **102** (or flag) and a sensor assembly **104** including a sensor housing **106** carrying a magnet **108**, a single pole **110**, and a magnetic sensor element **112**. In general, the sensor assembly **104** and target **102** may be mounted in a system, e.g. a seat position sensing system, in a manner allowing relative movement therebetween. For example, the target **102** may be coupled to a movable rail of a seat assembly or incorporated and/or integrally formed with at least a portion of the movable rail, and the sensor assembly **104** may be coupled to a stationary rail of a seat assembly. Alternatively, the target **102** may be coupled to the fixed rail of the seat assembly or incorporated and/or integrally formed with at least a portion of the fixed rail, and the sensor assembly **104** may be coupled to the moveable rail of the seat assembly.

When the target **102** is at a distance from the sensor assembly **104** a first level of magnetic flux from the magnet may be imparted to the magnetic sensor element **112**, resulting in a first output from the magnetic sensor element **112**. When the target **102** is positioned proximate the sensor assembly **104**, as shown, for example in FIG. **1**, the target **102** may cause an increased level of magnetic flux to be imparted to the magnetic sensor element **112**, compared to the first level of flux, resulting in a second output from the magnetic sensor element **112**. The output level of the magnetic sensor element **112** may thus be indicative of the position of the target **102** relative to the sensor assembly **104**. When, for example, the target **102** is positioned on a movable rail of a seat assembly (shown and described in greater detail later) and the sensor assembly **104** is affixed to a stationary rail of the seat assembly, the output of the magnetic sensor element **112** is indicative of the position of the movable rail and the seat affixed thereto, relative to the stationary rail.

With continued reference to FIG. **1**, the target **102** may be constructed from a ferromagnetic material and may be configured to move relative to the sensor assembly in a direction indicated by arrow A. The magnet **108** may be disposed at least partially in the housing **106** and may be magnetized in a direction indicated by arrow **A1** which is substantially parallel, e.g. within manufacturing and assembly tolerances, to the direction of movement of the target **102**. In one embodiment, for example, the magnet **108** may be magnetized such that a first end **114** represents a north (N) pole of the magnet and a second end **116** represents a south (S) pole of the magnet.

The single pole **110** may be constructed from a ferromagnetic material and may be of unitary or multi-piece construction. The pole **110** may be disposed in the housing at a fixed distance from the second end **116** of the magnet and within the magnetic field established by the magnet **108**. In the illustrated exemplary embodiment, the magnetic sensor element **112** is affixed to a printed circuit board (PCB) **118**. The PCB **118** may carry conductive paths and/or electronics for communicating the sensor element outputs to a controller **120** for controlling a vehicle system **122**, e.g. a vehicle air bag, seat position controller, etc., in response, at least in part, to the outputs of the magnetic sensor element **112**.

In one exemplary embodiment, the magnetic sensor element **112** may be configured as a Hall Effect sensor positioned on the PCB **118** with a flux receiving surface **124** of the sensor spaced from and in opposing relationship to an end surface **126** of the single pole **110**. The output of the Hall Effect sensor may vary in response to the level of flux density imparted to the flux receiving surface **124**. The flux receiving surface **124** of the sensor may thus be substantially parallel, e.g. within manufacturing and assembly tolerances, to the direction of magnetization of the magnet **108**, as indicated by arrow **A1**. Placing the magnetic sensor element **112** in this position relative to the direction of the magnetization of the magnet **108** can, compared to other orientations, reduce the vector component of the magnetic field from the magnet that affects the sensor.

In one exemplary embodiment, the Hall Effect sensor may be a well-known and commercially available solid state, low current device with diagnostic capability. A two terminal Hall Effect sensor may be used to achieve operation over a wide voltage and temperature range and provide two current output levels, e.g. 5.5 mA and 15 mA. A programmable Hall Effect sensor may be used to allow selection of the Hall switch point.

The housing **106** may include a cavity **128** for receiving the end surface **126** of the pole piece and the magnetic sensor element **112**. The PCB **118** may extend across the cavity **128** to opposing sides thereof, and may be sealed within the housing by a housing cover **130** (shown in FIG. **4**). Sealing of the cover **130** over the PCB **118** may be accomplished by a variety of means including, but not limited to, a perimeter seal, grommet, o-ring, epoxy, ultrasonic welding, over-molding, etc. The cover **130** may extend over the magnet **108** to seal the magnet **108** within the housing **106**. Alternatively, the cover **130** may be positioned so as to leave the magnet **108** exposed at an open side of the housing **106** to allow close positioning of the magnet **108** to the target **102**.

Referring to FIG. **2**, the target **102** may be positioned relative to the sensor assembly **104** to direct an increased magnetic flux through the magnetic sensor element **112**, with no intervening ferromagnetic pole between the sensor and the target, compared to when the target **102** is not in proximity to the sensor assembly.

FIG. **3** includes plots **300** and **302** of magnetic flux (gauss) at various distances from the end surface **126** of the pole **110**, i.e. moving in the direction of the target **102** shown in FIG. **1**. Plot **300** is a plot of gauss vs. distance from the pole **110** when a target **102** is present at 6 mm from the pole, and plot **302** is a plot of gauss vs. distance from the pole **110** when no target **102** is present. As shown, when the target **102** is present the flux is greater at distances from the end surface **126** of the pole **110**, i.e. in the location of the magnetic sensor element **112**, than when no target **102** is present. In addition, the difference (delta) between the flux present at a particular distance from the pole when the target **102** is present and when the target **102** is not present is about 80 gauss or more over a range of distances from 1 mm to 3 mm. The relative positioning of the components **108**, **110** and **112** may be chosen to achieve a desired delta (target present—not present) to accommodate a particular Hall Effect sensor selection, and/or a programmable Hall Effect sensor may be used to compensate for opening manufacturing tolerances.

FIGS. **4** and **5** illustrate an exemplary application of the target activated sensor system consistent with the present invention configured for sensing the position of a vehicle seat (not shown) affixed to a vehicle seat rail assembly **400**. FIG. **4** is an end view of a portion of the vehicle seat rail assembly **400** incorporating an exemplary target activated position sensor showing the target **102** positioned in proximity to the sensor assembly **104**. FIG. **5** is a side perspective view of the assembly of FIG. **4** showing the target **102** positioned at a distance from the sensor assembly **104**.

In the illustrated embodiment, the sensor assembly **104** is mounted on a movable rail **402** of the seat assembly **400** and moves relative to the target **102** (e.g., a flag) which is mounted to a fixed portion of the seat assembly **400**, e.g. via a fastener **404**. Alternatively, the sensor assembly **104** may be fixed and the target **102** may be movable. Also, one of the target **102** or sensor assembly **104** may be directly affixed to the stationary rail **406** of the seat assembly. Alternatively, the target **102** may be integrally formed with at least a portion of the movable rail **402** and the sensor assembly **104** may be mounted to the stationary rail **406**.

In the illustrated embodiment, the sensor assembly **104** may be mounted to the seat rail assembly **400** through a mounting bracket **412** via studs **414** (described in greater detail below). The target **102** may be positioned with a surface **408** thereof in opposed facing relationship to a bottom surface **410** of the sensor assembly **104** and the magnet **108** to establish an air gap G between the magnet **108** of the sensor assembly **104** and the target **102**. In one embodiment, the air gap G may be 3 mm±2 mm. Advantageously, however, a sensor system consistent with the invention may be configured with an air gap in excess of 5 mm. Use of a magnet **108** that is relatively long compared to its width contributes to the large air gap, while allowing use of a low grade magnet. In one embodiment, for example, the magnet **108** may have a length in its direction of magnetization of about 22-23 mm, a width of about 7-8 mm, and a height of about 9-10 mm.

FIG. **6** is an exploded view of one exemplary housing and mounting bracket configuration useful in connection with a target activated position sensor consistent with the present disclosure. In the illustrated embodiment, the mounting bracket **412** may be constructed from a ferrous or non-ferrous material and may be generally L-shaped including first **616** and second **618** arms. The first arm **616** of the bracket **412** may include openings **620** therein for receiving corresponding studs **414** extending from a side surface of the movable rail **402** of the seat assembly **400**. The studs **414** may pass through the openings **620** and may be secured against removal from the openings, e.g. by welding or an appropriate clip or fastener.

The second arm **618** of the bracket **412** may include first **622** and second **624** mounting openings for receiving first **626** and second **628** associated mounting flanges extending from the sensor housing **106**. Each of the mounting flanges **626**, **628** may be generally L-shaped having a first arm **630** and a second arm **632**. To mount the sensor assembly **104** to the bracket **412**, the first and second flanges **626**, **628** may be passed through the associated openings **622**, **624** and the first arms **630** may be positioned to overlay a top surface **634** of the bracket **412** adjacent the first and second openings **622**, **624**. Play between the mounting flanges **626**, **628** and the openings **622**, **624** may be removed by a positive locking clip **636** inserted between the flanges **626**, **628** and rear surfaces of the openings **622**, **624** and into the sensor housing **106**. Electrical connections from the PCB **118** to, for example, the controller **120** may be established through a connector **638** configured to securely mate with an associated receptacle **640** extending from the sensor housing **106**.

Advantageously, a sensor system with a single pole consistent with the present disclosure may be operated at a large air gap and may be provided in a compact package. In one embodiment for example, the sensor assembly **104**, as shown in FIG. **1** may have dimensions of about 15 mm×15 mm×35 mm, excluding the mounting flanges **626**, **628**. This small size is accommodating the limited space available in existing seat track assemblies.

Another advantage of the sensor assembly including a single pole consistent with the invention is robustness to manufacturing and assembly tolerances of the components. FIG. **7**, for example, includes plots of the delta (target present—not present) in gauss vs. eleven different variable component and assembly dimensions. Plots **700-720** are plots of delta vs. air gap, magnet length, magnet width, magnet height, pole height, pole width, pole thickness, the distance from a Hall sensor sensing element to the magnet, and the hall sensor x, y and z position tolerances, respectively, for an exemplary embodiment of a sensor assembly **104** consistent with the present invention. As shown, the delta shows little change if the eleven variables are varied up to ten times greater than the variation would be in production. In addition, the variables with the greatest affect on delta are generally component tolerances not assembly tolerances. Thus, a sensor consistent with the present invention enables less precision and more efficiency in manufacturing.

A sensor assembly consistent with the present disclosure may also be configured to operate using one of the movable or stationary rails **402**, **406** as the target without using a separate target **102** mounted to the rail or adjacent to the rail. In one embodiment, for example, the sensor assembly **104** may be connected to at least one of the rails **402**, **406** and sense the presence or absence of the other rail (either **402** or **406**) to avoid use of a separate target **102** to minimize cost.

FIG. **8** is a schematic side-sectional view of an exemplary sensor assembly consistent with the present disclosure and FIG. **9** is an exploded view of the assembly of FIG. **8**. This embodiment is similar to the embodiment of FIG. **1**, and like components have been assigned like reference numerals. Referring to FIG. **8**, the sensor assembly **804** includes a sensor housing **806**, a magnet **808**, a single pole **810**, a printed circuit board (PCB) **818**, a magnetic sensor element **812**, a carrier **830**, and an integral connector **832**.

The magnet **808** may be a magnet having a relatively small reversible temperature coefficient compared to a ferrite magnet, i.e. the magnet may to lose/gain less magnetic field value with temperature compared to a ferrite magnet. For example the magnet may be an NdFeB or SmCo magnet to allow the sensor to distinguish between the movable and fixed rails over a high temperature range even though the two rails are in close proximity to each other. Also, an NdFeB/SmCo magnet allows use of a physically small magnet and sensor size. The magnet **808** may be magnetized in the same manner and configuration as shown in FIG. **1** with respect to the magnet **108**, e.g. in a direction indicated by arrow A**1**, as shown with respect to the magnet **108** in FIG. **1**, which is substantially parallel, e.g. within manufacturing and assembly tolerances, to the direction of relative movement of the rail to be sensed by the sensor, or may be substantially perpendicular to the direction indicated by arrow A**1**. In one embodiment, for example, the magnet **808** may be magnetized such that a first end represents a north (N) pole of the magnet **808** and a second end represents a south (S) pole of the magnet **808**, e.g. in the orientation shown in FIG. **1**. Also, in one embodiment, the magnet **808** may be an 8×8×5 mm NdFeB magnet.

The single pole **810** may be constructed from a ferromagnetic material and may be of unitary or multi-piece construction. The pole **810** may be disposed in the housing **806** at a fixed distance from the end of the magnet **808** and within the magnetic field established by the magnet **808**. In one embodiment, the pole **810** may be 4 mm in diameter and about 7 mm long and machined from ferrous steel.

In the illustrated exemplary embodiment shown in FIGS. **8-9**, the magnetic sensor element **812** is affixed to the PCB **818**. The PCB **818** may carry conductive paths and/or electronics for communicating the sensor element outputs through contacts **936** coupled to the PCB **818** and exposed at the integral connector **832** to the controller **120** for controlling a vehicle system **122**, e.g. a vehicle air bag, seat position controller, etc., in response, at least in part, to the outputs of the magnetic sensor element **812**. In one exemplary embodiment, the magnetic sensor element **812** may be configured as a Hall Effect sensor positioned on the PCB **818** with a flux receiving surface of the sensor spaced from and in opposing relationship to an end surface of the single pole **810**. The output of the Hall Effect sensor may vary in response to the level of flux density imparted to the flux receiving surface. The flux receiving surface of the sensor may thus be substantially parallel or perpendicular, e.g. within manufacturing and assembly tolerances, to the direction of magnetization of the magnet **108**, as indicated by arrow A**1**.

Referring to FIG. **9**, the sensor assembly **804** includes a carrier **830** configured to be removably disposed in a cavity **928** of the housing **806** via an open end **929** of the housing **806**. The pole **810** and the magnet **808** may be provided in associated cavities **938**, **940**, respectively, defined in the carrier **830**. The carrier **830** may be at least partially disposed within. The carrier **830** and housing **806** may be molded from a plastic, e.g. a thermoplastic such as Nylon. The PCB **818** may extend across at least a portion of the cavity **928**, and may be sealed within the housing **806** by a housing cover **834**. Sealing may be accomplished by a variety of means including, but not limited to, a perimeter seal, grommet, o-ring, epoxy, ultrasonic welding, over-molding, etc.

FIGS. **10-11** are perspective views showing the assembly of FIG. **8** mounted relative to first and second rails of a seat rail assembly. FIG. **12** is a perspective view of a seat rail assembly consistent with the present disclosure. FIGS. **13** and **14** are perspective views of the assembly of FIG. **8** mounted relative to first and second rails of a seat rail assembly. In general, the sensor assembly **804** may be coupled directly to one of the rails **402**, **406** (shown in FIGS. **10-11**) for sensing the presence and/or absence of the other one of the rails. In the embodiment shown in FIGS. **10-14**, for example, the sensor **804** may be mounted to the movable rail **402** for sensing the presence or absence of the stationary rail **406**. When the stationary rail **406** is at a distance from the sensor assembly **804**, e.g. as shown in FIGS. **10** and **13**, a first level of magnetic flux from the magnet **808** may be imparted to the magnetic sensor element **812**, resulting in a first output from the magnetic sensor element **812**. When the stationary rail **406** is positioned proximate the sensor assembly **804**, as shown, for example in FIG. **11**, the stationary rail **406** may cause an increased level of magnetic flux to be imparted to the magnetic sensor element **812**, compared to the first level of flux, resulting in a second output from the sensor **812**. The output level of the magnetic sensor element **812** may thus be indicative of the position of the stationary rail **406** relative to the sensor assembly **804**. In the illustrated embodiment, when the sensor **804** is coupled to the movable rail **402** of a seat assembly, the output of the magnetic sensor element **812** is indicative of the position of the stationary rail **406** of the seat assembly relative to the movable rail **402**, thereby allowing the position of the seat relative to the stationary rail **406** to be determined.

In operation, the difference (delta) between the magnetic field value when the sensed rail is present and when it is not present determines the sensor operation at temperature extremes. The magnetic field that the Hall sensor sees is also a function of the operating air gap and surrounding ferrous materials. Advantageously, the magnetic circuit, i.e. the path of the flux from the magnet through the pole and rails may be configured so that a ferrous member is not necessary at the back of the sensor.

In the illustrated embodiment, the sensor assembly **804** may be coupled to one of the rails **402**, **406** by a flexible plastic (e.g. a molded thermoplastic such a Nylon) bracket **1000** having a first end **1002** coupled to at least a portion **1004** of the housing **806** of the sensor assembly **804**. The plastic bracket **1000** also includes a second end **1006** coupled to at least a portion of one of the rails **402**, **406**. Referring to FIGS. **13** and **14**, the first end **1002** of the plastic bracket **1000** may define a bracket rail **1300** configured to slidably engage a housing rail **1302** defined on a portion **1004** of the housing **806** of the sensor assembly **804**. The bracket and housing rails **1300**, **1302** are shaped and/or sized to slidingly cooperate, allowing the sensor assembly **804** to be adjusted to multiple positions relative to the coupling position where the second end **1006** of the bracket **1000** is coupled to at least a portion of one of the rails **402**, **406** (shown in FIG. **15**). Referring to FIG. **15**, the sensor assembly **804** may be coupled to the bracket **1000** such that the sensor **804** may be configured to move relative to the bracket **1000** in a direction indicated by arrow A from a first bracket position **1000***a* to at least a second bracket position **1000***b*.

FIGS. **16-17** illustrate various mechanical connections for coupling a sensor assembly consistent with the present disclosure to a rail of a vehicle seat rail assembly. Referring to FIG. **16**, the flexible bracket **1000** may be mechanically attached to the sensor assembly **804** and/or first and/or second rails of the vehicle seat rail assembly. As generally understood by one of ordinary skill in the art, various means of mechanical attachment may be used, such as using a fastener or plastic clip or screws or rivets. Referring to FIG. **17**, the flexible bracket **1700** may be over-molded to the sensor assembly **804**.

The flexible bracket **1000** may be resiliently adjusted to optimize the positioning of the sensor assembly **804** in a variety of different vehicle seat rail assemblies and/or platforms. The flexible bracket **1000** thus allows the sensor assembly **804** to be adjustably positioned relative to the rails **402**, **406** to provide flexibility in the Hall switch point, operating air gap and clearance from the carpet/vehicle floor. The magnetic field delta between the two sensor states may thus be maximized providing a magnet **808** having a relatively small reversible temperature coefficient compared to a ferrite magnet, e.g. a NdFeB or SmCo magnet, and selecting the sensor component geometry and location to ensure operation for a wide range of temperatures and air gap tolerances.

In one aspect, the present disclosure may feature a sensor assembly configured to sense a position of a seat in a vehicle. The sensor assembly may include a housing defining a cavity and having an open end. The sensor assembly may also include a carrier removably disposed in the housing cavity via the open end, wherein a permanent magnet may be disposed within a magnet cavity defined in the carrier, wherein the permanent magnet may establish a magnetic field. The sensor assembly may further include a single pole disposed within a pole cavity defined in the carrier and spaced from the permanent magnet and positioned in the magnetic field. In addition, the sensor assembly may include a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in the magnetic field and adjacent to an end of the single pole. The magnetic sensor element and PCB may be at least partially disposed within the cavity.

In yet another aspect, the present disclosure may feature a system for sensing a position of a seat in a vehicle. The system may include a vehicle seat rail assembly configured to movably couple the seat to the vehicle. The vehicle seat rail assembly may include a first rail and a second rail, wherein the first rail may be configured for movement with the seat relative to the second rail. The system may further include a sensor assembly coupled to one of the first rail or the second rail. The sensor assembly may include a housing defining a cavity and having an open end. The sensor assembly may also include a carrier removably disposed in the housing cavity via the open end, wherein a permanent magnet may be disposed within a magnet cavity defined in the carrier, wherein the permanent magnet may establish a magnetic field. The sensor assembly may further include a single pole disposed within a pole cavity defined in the carrier and spaced from the permanent magnet and positioned in the magnetic field. In addition, the sensor assembly may include a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in the magnetic field and adjacent to an end of the single pole. The magnetic sensor element and PCB may be at least partially disposed within the cavity. When the first rail is in a first position relative to the second rail, the magnetic sensor element may be configured to provide a first output in response to a first level of magnetic flux from the magnet directed to the magnetic sensor element. When the first rail is in a second position relative to the second rail, the magnetic sensor element is configured to provide a second output different from the first output in response to a second level of magnetic flux from the magnet directed to the sensor element.

In another aspect, the present disclosure may feature a method of sensing a position of a seat in a vehicle. The method may include providing a sensor assembly coupled to one of a first rail or a second rail of a vehicle seat rail assembly configured to be movably coupled to the seat of the vehicle, the first rail configured for movement with the seat relative to the second rail. The sensor assembly may include a housing defining a cavity and having an open end. The sensor assembly may also include a carrier removably disposed in the housing cavity via the open end, wherein a permanent magnet may be disposed within a magnet cavity defined in the carrier, wherein the permanent magnet may establish a magnetic field. The sensor assembly may further include a single pole disposed within a pole cavity defined in the carrier and spaced from the permanent magnet and positioned in the magnetic field. In addition, the sensor assembly may include a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in the magnetic field and adjacent to an end of the single pole. The magnetic sensor element and PCB may be at least partially disposed within the cavity.

The method may further include providing a first output using the magnetic sensor element in response to a first level of magnetic flux from the magnet directed to the magnetic sensor element when the first rail is in a first position relative to the second rail. The method may further include providing a second output different from the first output using the magnetic sensor element in response to a second level of magnetic flux from the magnet directed to the magnetic sensor element when the first rail is in a second position relative to the second rail. Additionally, the method may include determining the position of the seat via the first and second outputs provided by the magnetic sensor element.

While several embodiments of the present invention have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the functions and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the present invention. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the teachings of the present invention is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the invention described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, the invention may be practiced otherwise than as specifically described and claimed. The present invention is directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the scope of the present invention.

All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified, unless clearly indicated to the contrary.

What is claimed is:

1. A system for sensing a position of a seat in a vehicle, said system comprising:

a vehicle seat rail assembly configured to movably couple said seat to said vehicle, said vehicle seat rail assembly comprising a first rail and a second rail, wherein one of said first rail or said second rail is moveable with respect to the other; and

a sensor assembly coupled to said first rail, said sensor assembly comprising:

a housing defining a cavity;

a carrier disposed in said housing;

a permanent magnet disposed within a magnet cavity defined in said carrier, said permanent magnet establishing a magnetic field;

a single pole disposed within a pole cavity defined in said carrier and spaced from said permanent magnet and positioned in said magnetic field;

a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in said magnetic field and adjacent to an end of said single pole, said magnetic sensor element and said PCB at least partially disposed within said cavity; and,

a plastic bracket having a first and a second end, said first end of said plastic bracket defining a bracket rail configured to slidably engage a housing rail defined on said housing and to allow adjustment of said sensor assembly relative to a coupling position of said sensor assembly and bracket to one of said first rail or said second rail, and said second end configured to be coupled to at least a portion of said first rail;

wherein, when said first rail is in a first position relative to said second rail, said magnetic sensor element is configured to provide a first output in response to a first level of magnetic flux from said magnet directed to said magnetic sensor element;

wherein, when said first rail is in a second position relative to said second rail, said magnetic sensor element is configured to provide a second output different from said first output in response to a second level of magnetic flux from said magnet directed to said magnetic sensor element.

2. The system of claim **1** wherein said sensor assembly further comprises an integral connector configured to provide said first output and said second output from said PCB to a vehicle controller.

3. The system of claim **1** wherein said magnetic sensor element comprises a Hall Effect sensor.

4. The system of claim **3** wherein said Hall Effect sensor comprises a flux receiving surface and being responsive to said first and second levels of magnetic flux imparted to said flux receiving surface to provide said first and second outputs.

5. The system of claim **1** wherein said magnet comprises material selected from the group consisting of NdFeB and SmCo.

6. A sensor assembly configured to sense a position of a seat in a vehicle, said sensor assembly comprising:
- a housing defining a cavity configured to be coupled to a first rail of a vehicle seat rail assembly, wherein one of said first rail or a second rail of said vehicle seat rail assembly is moveable with respect to the other;
- a carrier removably disposed in said housing cavity;
- a permanent magnet disposed within a magnet cavity defined in said carrier, said permanent magnet establishing a magnetic field;
- a single pole disposed within a pole cavity defined in said carrier and spaced from said permanent magnet and positioned in said magnetic field; and
- a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in said magnetic field and adjacent to an end of said single pole, said magnetic sensor element and said PCB at least partially disposed within said cavity;
- a plastic bracket having a first and a second end, said first end defining a bracket rail configured to slidably engage a housing rail defined on said housing and to allow adjustment of said sensor assembly relative to a coupling position of said sensor assembly to one of said first rail or said second rail, and said configured to be coupled to at least a portion of said first rail.

7. The sensor assembly of claim **6** wherein said sensor assembly is configured to be coupled to one of said first rail or said second rail of a vehicle seat rail assembly configured to movably coupled said seat to said vehicle, said first rail configured for movement with said seat relative to said second rail.

8. The sensor assembly of claim **7** wherein, when said first rail is in a first position relative to said second rail, said magnetic sensor element is configured to provide a first output in response to a first level of magnetic flux from said magnet directed to said magnetic sensor element and wherein, when said first rail is in a second position relative to said second rail, said magnetic sensor element is configured to provide a second output different from said first output in response to a second level of magnetic flux from said magnet directed to said magnetic sensor element.

9. The sensor assembly of claim **6**, wherein said plastic bracket is over-molded onto said housing.

10. The sensor assembly of claim **6** further comprising an integral connector configured to provide said first output and said second output from said PCB to a vehicle controller.

11. The sensor assembly of claim **6** wherein said magnet comprises material selected from the group consisting of NdFeB and SmCo.

12. The sensor assembly of claim **6** wherein said magnetic sensor element comprises a Hall Effect sensor.

13. The sensor assembly of claim **12** wherein Hall Effect sensor comprises a flux receiving surface and being responsive to said first and second levels of magnetic flux imparted to said flux receiving surface to provide said first and second outputs.

14. A method of sensing a position of a seat in a vehicle, said method comprising:
- providing a sensor assembly comprising:
  - a housing defining a cavity;
  - a carrier disposed in said housing cavity;
  - a permanent magnet disposed within a magnet cavity defined in said carrier, said permanent magnet establishing a magnetic field;
  - a single pole disposed within a pole cavity defined in said carrier and spaced from said permanent magnet and positioned in said magnetic field;
  - a magnetic sensor element affixed to a printed circuit board (PCB) and positioned in said magnetic field and adjacent to an end of said single pole, said magnetic sensor element and said PCB at least partially disposed within said cavity; and
  - a plastic bracket having a first and a second end, said first end of said plastic bracket defining a bracket rail;
- securing said second end of said plastic bracket to at least a portion of a first rail of a vehicle seat rail assembly configured to be movably coupled to said seat of said vehicle, wherein one of said first rail or a second rail of said vehicle seat rail assembly is configured to move with respect to the other;
- slidably engaging said bracket rail with said housing rail to allow adjustment of said sensor assembly relative to a coupling position of said sensor assembly and bracket to one of said first rail or said second rail; and
- providing an output using said magnetic sensor element, wherein said output is representative to sense a flux density that varies based on a presence or an absence of said second rail within said magnetic field.

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